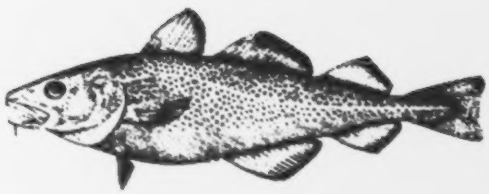
RECOVERY POTENTIAL ASSESSMENT FOR THE NEWFOUNDLAND AND LABRADOR DESIGNATABLE UNIT (NAFO DIVS. 2GHJ, 3KLNO) OF ATLANTIC COD (*GADUS MORHUA*)



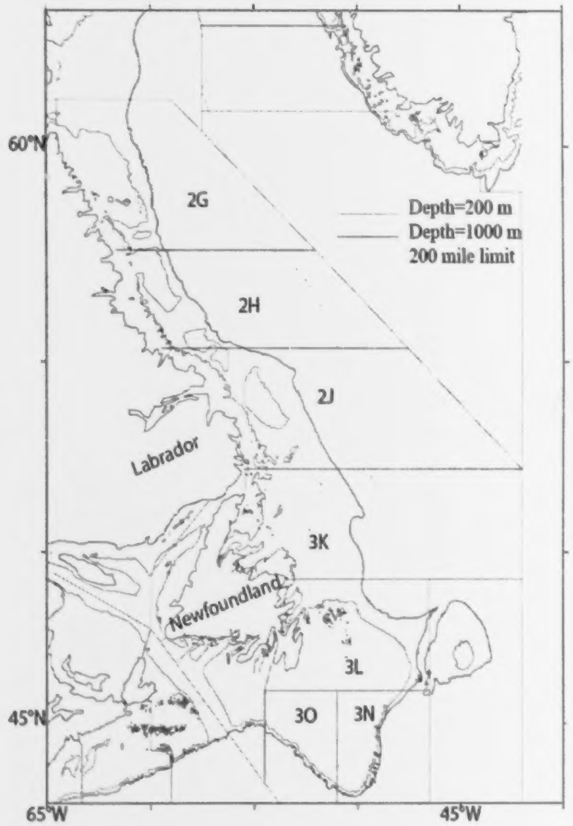


Figure 1. Cod stock management areas 2GHJ, 3KLNO that constitute the Newfoundland and Labrador designatable unit.

Context :

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recently (2010) re-assessed the status of Atlantic Cod stocks in Canada and classified the Newfoundland and Labrador designatable unit as Endangered. Environment Canada in consultation with Fisheries and Oceans Canada (DFO), is the responsible jurisdiction under the Species at Risk Act (SARA), and is, therefore, required to decide, within a specific timeframe, whether to formally list the population under SARA. In support of the listing recommendation, a number of actions are required, many of which require scientific information on issues such as the current status of the species, population or designatable unit (DU),

threats to its survival and recovery, and the feasibility of its recovery. Formulation of this scientific advice has typically been developed through a Recovery Potential Assessment (RPA) that is conducted shortly after the COSEWIC assessment. This timing allows for the consideration of peer-reviewed scientific analyses into SARA processes including recovery planning.

In support of listing recommendations for Atlantic Cod, DFO Science has been asked to undertake a RPA on the Newfoundland and Labrador DU which encompasses three management units, namely 2GH, 2J+3KL and 3NO (see Fig. 1). The advice in the RPA may be used to inform both scientific and socio-economic elements of the listing decision, as well as development of a recovery strategy and action plan, and to support decision-making with regards to the issuance of permits, agreements and related conditions, as per relevant sections of SARA.

SUMMARY

- The Newfoundland and Labrador (NL) DU of Atlantic Cod comprises three stocks or management units: Labrador cod (NAFO Divs. 2GH), Northern cod (Divs. 2J+3KL) off southern Labrador and eastern Newfoundland both managed by Canada, and southern Grand Banks cod (Divs. 3NO) managed by the Northwest Atlantic Fisheries Organization (NAFO). The Northern cod population was by far the largest in the NL DU, and was historically the largest cod population in the northwest Atlantic.

- Long-term projections were undertaken for the 2J+3KL and 3NO stocks and at the DU level based on a combination of results from these stocks. Future productivity conditions are very uncertain. Thus, these projections should not be interpreted as forecasts of future stock status as they depend on assumptions about future productivity and fishing mortality. The probability of current conditions continuing for a long period of time is unknown. These projections are explorations of the consequences of particular productivity assumptions.

- Projections are illustrated using the median and the 2.5th and 97.5th percentiles. The full range of uncertainty should be considered when interpreting these projections.

- The demersal juvenile stage (4 - 35 cm long) is the most habitat-dependant period in the life-cycle of Atlantic Cod. Physical disturbance of structural components of habitat can reduce its value and increase mortality of juvenile cod. Existing data lack the spatial resolution required to evaluate the amount of suitable habitat available to demersal juveniles and whether it has changed in the past three generations, especially in the offshore. However, there is no indication that the amount of suitable habitat is currently limiting recovery of cod in this DU.

Labrador cod (2GH)

- Information on the Labrador cod stock is sparse and there is no survey time series from which to evaluate trends. Reported landings of cod from this stock declined in the late 1960s and there have been no reported landings since the late 1980s. This stock has shown no sign of recovery since a moratorium on directed fishing was imposed in 1993.

Northern cod (2J+3KL)

- The Northern cod stock declined by over 99% since the peak in the late 1960s, and by over 90% compared to the 1980's. The population remained very low for several years after the moratorium, but has shown slight improvement during 2005-08.

- A conservation limit reference point (LRP) has been established for Northern cod. Estimated SSB has been well below the LRP since the early 1990s, but SSB increased during 2005-08 and is currently 90% below the LRP.

- Total mortality rates of Northern cod based on a cohort analysis of survey catches have been high through much of the 1983-2009 period, with two peaks, one in the early 1990's and a second during the early 2000s when directed inshore fisheries were reopened. Total mortality rates declined during 2003-05 when inshore fishing was more restricted; total mortality rates remained low during 2005-08.

- There are no direct estimates of natural mortality for Northern cod. However, total mortality remained low during 2005-08 in spite of a reopening of inshore fisheries, suggesting that natural mortality rates declined substantially. Estimates of fishing mortality based on tagging have been low for cod tagged inshore (<0.1 since 2007) and offshore (0.06 in 2008) and spawning stock biomass (SSB) has improved.

- Recruitment has remained low since the early 1990s. Other components of productivity such as length-at-age, weight-at-age and condition have improved since the low values of the early 1990s and were close to (Div. 2J) or above average (Divs. 3K and 3L) for several years, but declined in 2009. Age at 50% maturity for female cod declined in cohorts produced during the 1980s and remains low (~5.0) compared to earlier decades (>6.0).

- For the 2J+3KL stock, using 1983-2009 as the period to infer future productivity conditions and under the current fishing mortality rate (F=0.06), projections indicate an initial increase in SSB until 2016 followed by a decline and stabilization at a level lower than current SSB. In 2016 there is a low probability (approx. 10%) of reaching the LRP. At F=0 the probability of reaching the LRP is about 30% in 2016.

- Additional sensitivity analyses were conducted using conditions observed during various portions of the 1983-2009 period. The most optimistic of these analyses assumed that low natural mortality rates, similar to those estimated for 2005-09, would prevail over the next 36 years. For F=0, 65% of the projection results indicated the LRP will be exceeded in the next 36 years. For F=0.06, 40% of the results indicated the LRP will be exceeded. However, it is less likely that conditions in the recent period will persist the further the projection proceeds into the future.

Southern Grand Banks cod (3NO)

- The 3NO cod stock peaked in the 1960s but decline to < 20% of 1960s values by the mid-1970s. The population increased rapidly during the late 1970s but declined again steeply during the late 1980s and remained low throughout the 1990s to about 2005. In recent years the stock has increased and the average number of spawners in the last 3 yrs (2008-10) is 25% of the 1980-89 average.

- A conservation limit reference point (B_{lim}) was established for the 3NO cod stock in 1999 at 60,000 t. Estimated SSB has been well below the LRP since the early 1990s, but SSB increased recently and is currently 79% below B_{lim}.

- Trends in total mortality rate of 3NO cod show two peaks, with higher values during 1965-75 and during the late 1980s. During the late 1970s and early 1980s, total mortality rates were much lower. Total mortality rate has been low since the moratorium, except during 2003.

- Although *F* in the post-moratorium period is generally low, recent bycatch fisheries generated high levels of *F* in some years, coincident with pulses of improved recruitment. Fishing mortality from bycatch has contributed significantly to the lack of recovery since the moratorium.

- Recruitment for 3NO cod has generally remained low for several years since the early 1990s. However, the 2005 and 2006 year classes are stronger and these have not been heavily fished and are now contributing significantly to the recent improvements in SSB.

- For the 3NO stock, using 1974-2009 as the period to infer future productivity conditions and under the current fishing mortality rate (F=0.07), there is a sustained rapid increase in SSB and all projection results suggest that B_{lim} is surpassed by 2016. For the F=0 scenario, the trends are similar but increases are larger and all projections results suggest B_{lim} is surpassed by 2015.

NL DU (2GHJ3KLNO)

- Projected status of the DU was inferred by combining the stock-specific projections of spawning stock numbers. Under the current levels of fishing, spawning stock numbers increase and peak in 2026. Under F=0 overall trends are similar, but reach a higher peak. Although the historic 2J+3KL stock was much larger than the 3NO stock, these results at the DU level are dominated by the much more optimistic trajectory in 3NO.

- For both 3NO and 2J+3KL, age at maturity has declined and remained low and increased mortality associated with spawning at these younger ages may be expected.

- The greatest threats to the recovery of the NL DU cod are high level of natural mortality (in 2J+3KL) and fishing mortality (in 2J+3KL and 3NO). Fishing mortality occurs primarily through directed stewardship and recreational fisheries in 2J+3KL and as bycatch in 3NO.

- In consideration that both populations have recently shown increases, there appears to be scope for allowable harm permitting, if current levels of productivity continue. Catches that have resulted in current levels of fishing mortality, (estimated as F=0.06 for 2J+3KL cod, F=0.07 for 3NO cod), would not appear to be sufficient to jeopardize survival or recovery of the species in the short term (3-years). This should allow sufficient time for recovery plans to be developed.

BACKGROUND

Rationale for Assessment

The status of the COSEWIC designatable unit of Atlantic Cod was re-evaluated in April 2010, and COSEWIC concluded that cod in the NL DU had declined by 97-99% in the past three generations, by more than 99% since the 1960's, and was therefore assigned a status of Endangered. The NL DU (which is a designation by COSEWIC) was also evaluated by COSEWIC as Endangered in 2003. Previously, Atlantic cod as a species was considered a single unit and designated as Special Concern in April 1998.

As part of this assessment process, scientific information is needed to support the development and assessment of social and economic cost and benefit of potential management scenarios for recovery, to better inform public consultations and to support other entities involved in the decision of whether to add the species to Schedule 1 of SARA. The information will be used to develop a recovery strategy, and if necessary, one or more action plans.

The general intent of this document is to provide scientific advice in support of listing recommendations and includes information required for development of a Recovery Strategy, should it be deemed necessary. Most of the material in this document is derived from the latest peer-reviewed stock assessments for the relevant cod management units.

Species Biology

Cod occur widely in cool temperate waters overlying continental shelves off Newfoundland and Labrador and elsewhere in the North Atlantic, and can be found from the shoreline to depths exceeding 600 m. Spawning and egg and larval development occur in the water column, thereafter, cod settle to the bottom where they prefer heterogeneous habitats that reduce predation risk. As adults, habitat requirements become increasingly diverse and life history becomes more variable.

Historically, much of the stock off Newfoundland and Labrador was highly migratory. They over-wintered in dense aggregations near the edge of the continental shelf and migrated in spring/summer to shallow waters along the coast and onto the plateau of Grand Bank.

Cod off Labrador (2GH, 2J) and eastern Newfoundland (3KL) and the Grand Banks (3NO) show an increasing growth rate north to south, but grow slowly compared with individuals in the warmer waters in the eastern Atlantic and further south in the western Atlantic. Since the late 1980s, females have been maturing at about age 5, which is younger than in previous years.

Small cod tend to feed on small crustaceans; medium-sized cod feed on larger crustaceans and small fish; and large cod feed on medium-sized fish and crabs. Capelin in particular has historically been an important part of the annual diet. Small cod are eaten by squid, many species of groundfish, including larger cod, and some species of birds. Larger juveniles are eaten by larger groundfish, seals and other marine mammals. Large cod probably have few natural predators, but seals can prey upon them by belly-feeding.

NL DU

Cod populations that make up the NL DU extend from the northern tip of Labrador to the southern Grand Banks (Fig. 1). Cod in this area are managed as three stocks: NAFO Divs. 2GH off northern Labrador and Divs. 2J+3KL off southern Labrador and eastern Newfoundland, both managed by Canada, and Divs. 3NO managed by NAFO (Fig. 1).

The 2J+3KL population of Atlantic Cod was by far the largest in the NL DU, and was considered to have been historically the largest cod population in the northwest Atlantic. Stocks in 2J+3KL are assessed annually and in 3NO are assessed tri-annually with updated monitoring assessments occurring in the interim years. The population in 2GH is near the northerly limit of the range of the species in Atlantic Canada (aside from relict populations in Arctic lakes) and has not been assessed since 1996 and scientific information on this stock is sparse.

ASSESSMENT

Status and Trends

For the cod stock in 2GH, there is no time series of survey data to evaluate trends in status. Scientific information is limited to intermittent surveys with partial coverage, and these were often directed at species other than cod. This stock was commercially extinct by the late 1980s. There have been small amounts of cod bycatch in shrimp fisheries in this area but available evidence, though sparse, indicates no improvement in status of this population.

For the other two stocks (2J+3KL and 3NO cod), trends in the population were evaluated using a cohort model for 2J+3KL cod based on autumn research vessel survey catches (1983-2009), and using a virtual population analysis (VPA) for 3NO cod based on commercial catches (1959-2009) and research vessel survey data (1984-2009).

For the 2J+3KL stock, the spawning stock numbers (SSN) increased through the 1980's, partly as a result of increases in the proportion of young fish that were mature (see Life History Parameters), but SSN declined steeply from 1989 until the early 1990s and, thereafter, remained low (Fig. 2, left panel). Since 2005, the SSN have increased slightly and the average in the last 3 years (2007-09) is 12% of the 1983-89 average.

Historically, the offshore populations constituted the vast majority of the stock but after the collapse, cod older than age 6 were rarely observed in the offshore. During the mid-1990s to the early 2000s, aggregations of adult cod were observed in the inshore and these populations were considered functionally distinct from those in the offshore. Tagging studies and VPA based on inshore catches were used to estimate F and M in the inshore during 1998-2002 when reported landings ranged from 4,000-8,500 t. These analyses indicated that F increased during this period to between 0.2 (from tagging) and 0.3 (from VPA). Natural mortality estimated from tagging was 0.4 in 3K and 0.3 in 3L. These analyses indicated that inshore components of the stock were small and not sufficiently productive to sustain the catches taken during 1998-2002. Recently, offshore components of the stock have shown some improvement and their traditional historical pattern of seasonal migration to the inshore has been observed; offshore components are now considered to comprise the bulk of the population.

For 3NO, the SSN averaged around 30 million in the 1960s, but declined to <5 million by the mid-1970s (Fig. 2, right panel). Following extension of jurisdiction to 200 miles, the SSN increased rapidly, reaching approximately 25 million by the early 1980s. SSN declined steeply during the 1980s and remained below 5 million throughout the 1990s to about 2005. In recent years, SSN has increased and the average number in the last 3 years (2008-10) is 25% of the 1980-89 average.

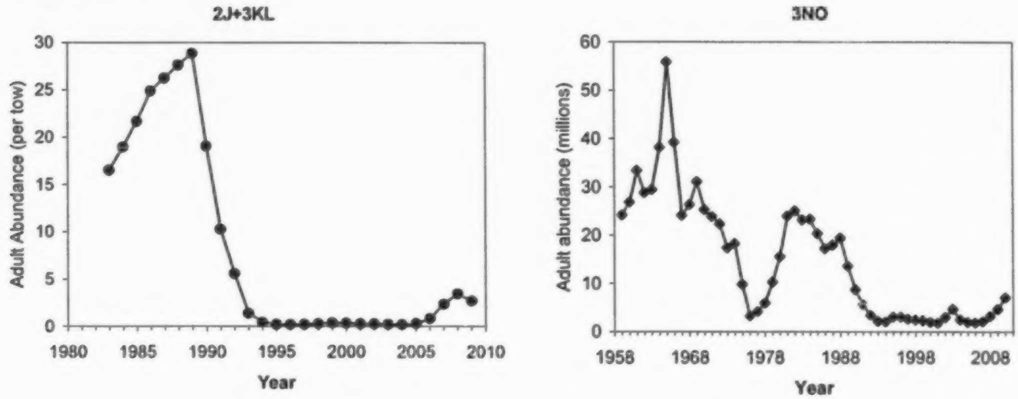


Figure 2. Trends in Spawning Stock Numbers (SSN) for Atlantic Cod for two populations in the NL DU. Results for Divs. 2J+3KL are from a cohort analysis of fall survey data and are shown as numbers per tow, whereas those from Divs. 3NO are from a population model (VPA). There are no comparable data for the population in 2GH.

Trends in biomass of adult cod for 2J+3KL and 3NO were almost identical to those described above for numbers (abundance) and are not shown here.

Historic and Current Distribution and Trends

Atlantic Cod in 2J+3KL and 3NO were widely distributed over the surveyed area in most years (Fig. 3). In both managed stocks there was a decline in the proportion of area occupied during the late 1980s with minimum values in 1994. Survey gear was changed in the mid-1990s in both surveys; although catches in the earlier portion have been converted to Campelen equivalents, the Campelen gear was more efficient at catching small cod, especially age 0 and 1, and these may be underestimated in the period prior to the switch in survey gear. After the mid-1990s, values for proportion of area occupied are variable, especially for 3NO. The most recent values of 60-70% for 2J+3KL and 55-60% for 3NO are slightly lower than the area occupied during the early 1980s, but for both stocks there is a slight increasing trend since the mid-1990s.

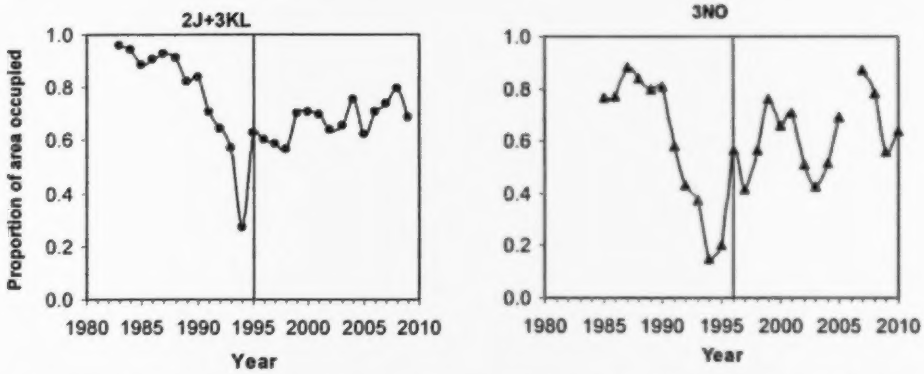


Figure 3. Proportion of survey area occupied by populations of Atlantic Cod in the NL DU (there are no comparable data for 2GH). Survey in 2006 in 3NO was incomplete and not considered representative. Vertical line indicates change in gear from Engels to Campelen trawl and two time series may not be directly comparable.

Comparison of research vessel survey catches from the mid-1980s with the most recent surveys (2009) indicate that, although different survey gears were used (see above) cod are widespread in the survey area in both time periods. The numbers tend to be much lower in the most recent survey (Fig. 4, right panels). In the 2009 survey of 2J+3KL cod, larger catches are restricted mainly to a narrow portion of the surveyed area adjacent to the 3KL border (Fig. 4, upper right panel). Similarly, in 3NO larger catches in the recent period are restricted to the deeper water along the slope edge of the continental shelf (Fig. 4, lower right panel).

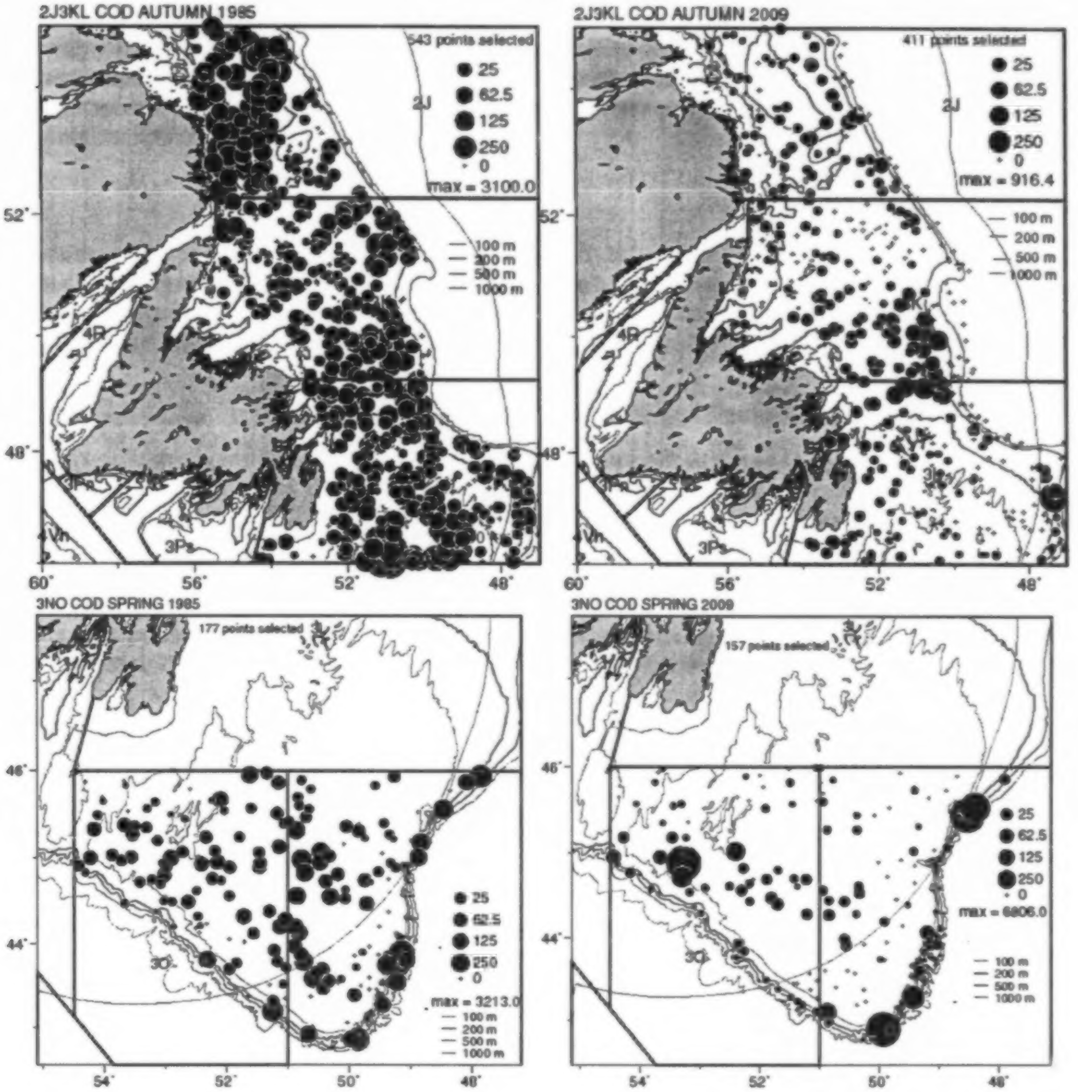


Figure 4. Comparison of historical (1985) versus recent (2009) cod distribution (number per standard tow) during the autumn research survey in NAFO Divisions 2J+3KL (upper panels) and the spring research survey in Divs. 3NO (lower panels).

Stock Structure

The cod stock in 2J+3KL is considered a meta-population with multiple components that show limited connectivity. There is evidence that there are cod populations in the inshore that are functionally distinct from those in the offshore. Inshore populations are small relative to the populations that historically migrated into the inshore from the offshore during spring/summer but during the post-moratorium period (mid-1990s to early 2000s) these inshore components likely constituted a much larger fraction of a smaller overall stock.

Tagging studies revealed that during the late 1990s to the mid-2000s the inshore of 3KL was inhabited by at least two groups of cod: (1) a resident coastal group that inhabited an area from eastern Trinity Bay northward to western Notre Dame Bay (Fig. 3); and (2) a migrant group that over-wintered in inshore and offshore areas of 3Ps, moved into southern 3L during late spring and summer, and returned to 3Ps in the autumn. Tagging studies also indicated considerable movement of cod among Trinity Bay, Bonavista Bay and Notre Dame Bay.

Recent findings from tagging and acoustic telemetry indicate that the historical shoreward seasonal migration pattern of the pre-moratorium period did occur during 2008 and 2009. The offshore biomass of cod in 2J3KL is low but increased during 2003-08; the contribution of offshore cod to the inshore biomass during summer likely increased during this period.

There is less information on stock structure for 3NO cod, although this population is generally thought to be less heterogeneous than the stock complex in 2J+3KL.

Life history parameters

Total mortality

For the 2J+3KL stock, estimates of the total mortality rate (*Z*) from the cohort analysis for two age groups indicate that the annual instantaneous rate of mortality was variable (0.4 to 1.0) during 1983-89, increased further to >2.0 during 1990-94, then declined to around 0.5 during 1995-2000 (Fig. 5, right panel). There is a notable switch from higher values of *Z* among older ages (5-11) prior to the moratorium to higher values among younger ages (2-4) subsequent to the moratorium, although the trends for the two age groups are similar. Values for *Z* increased to between 0.9 and 1.5 during 2002-03 then declined. The values of *Z* for 2006-08 are generally <0.4 and lower than those observed in the 1980s. Overall, the total mortality rate has declined in the recent period (2006-09) indicating that the rate of natural mortality has declined substantially. The higher average *Z* in 2009 is caused by high *Z*'s estimated at ages 6-12.

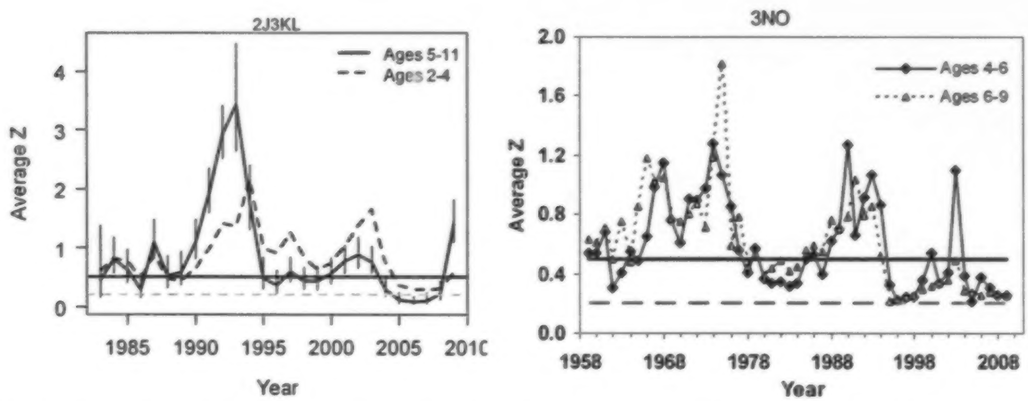


Figure 5. Trends in the total mortality rate (Z) of cod in 2J+3KL (left panel) and 3NO (right panel). Reference lines are provided at Z=0.5 (solid horizontal line) and Z=0.2 (dashed horizontal line) correspond to annual mortality rates of 39% and 18%, respectively.

For 3NO cod, total mortality rates were obtained by adding the assumed annual value for natural mortality of M=0.2 to the annual estimates of F for two age groups from the VPA (Fig. 5, right panel). Trends in Z show two peaks with Z generally above 0.8 during 1965-75 and in 1989-94. Since the moratorium in 1993, Z has generally been below 0.5, except for 2003 when increased bycatch of cod caused a spike in Z to >1.0. Values of Z in the 2004-10 period have remained <0.4.

Recruitment

Cohort analysis and a year-class strength model indicate that for 2J+3KL cod, year class strength was variable but generally much higher in the early to mid-1980s (Fig. 6a, upper panel). For the post moratorium period (Fig. 6, lower panel) year class strength has been poor, although the expanded scale in the lower panel suggests that some of the year classes produced during 2002-06 are marginally stronger than others produced during this period.

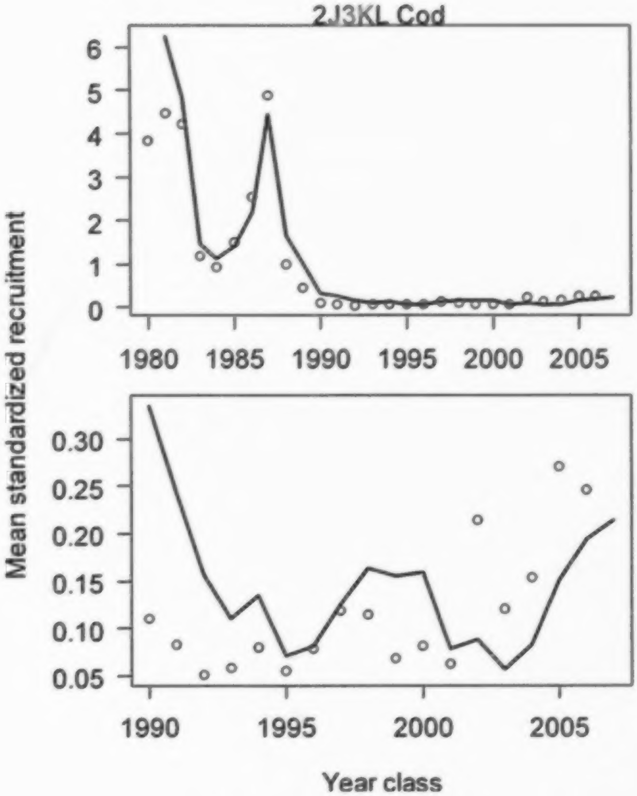


Figure 6. Trends in recruitment (age 2) for 2J+3KL cod. Circles are observed values from year class strength model and solid lines are SURBA+ estimates. The top panel shows the results for the entire time-series. The lower panel compares the results for the more recent period (1992 onwards).

For 3NO cod, the time series of recruitment estimates (nos. at age 3) from the VPA extends back to the late 1950s and shows a long-term decline following a peak in the early 1960s (Fig. 7, upper panel). Almost all year classes produced since the early 1990s have been weak, although the 2005 and 2006 year classes are slightly stronger (Fig. 7, lower panel).

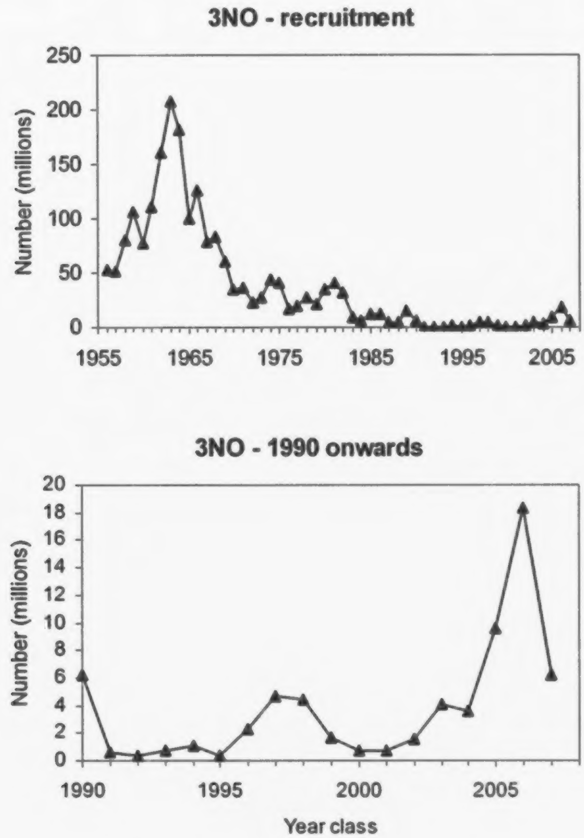


Figure 7. Trends in recruitment (age 3) from VPA for 3NO cod.

Maturity

For both 2J+3KL and 3NO the proportion of female cod that are mature at young ages has increased over time particularly among cohorts produced from the late 1980s onward (Fig. 8). Age-at-maturity has declined from about age 6-7 in the early part of the time series to between 4.5 - 5.7 for both 2J+3KL and 3NO in all cohorts produced since the late 1980s. Males generally mature about one year younger than females and show a similar trend over time (not shown). The reasons for the change towards earlier age at maturity are not fully understood. The change may have a genetic component and partly be associated with high levels of mortality and low stock size.

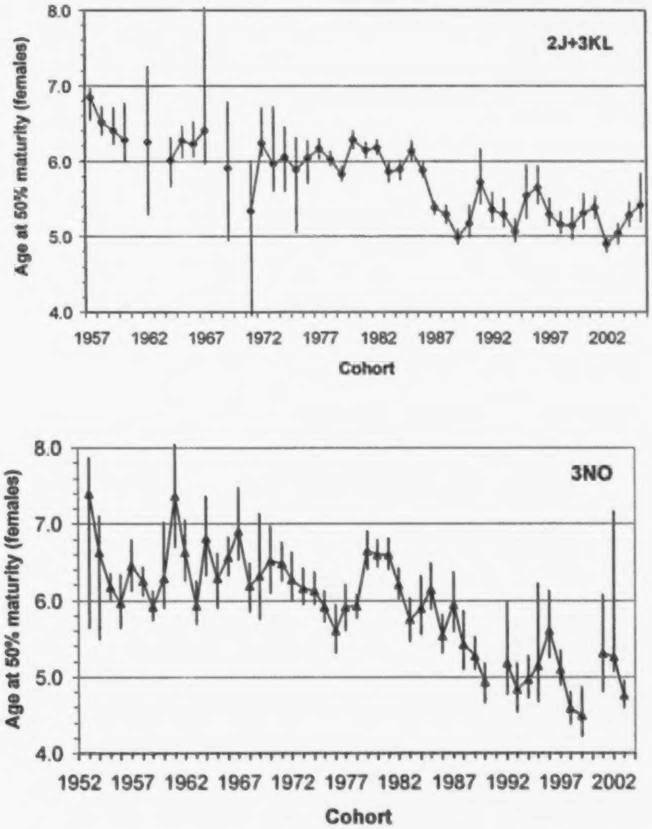


Figure 8. Age at 50% maturity (± 95% CI) by cohort for female cod in Divisions 2J+3KL (upper panel) and Divs. 3NO (lower panel) based on sampling during research vessel surveys.

Other life history parameters and biological characteristics such as growth rates and condition have also been examined at recent assessments. For 2J+3KL cod growth and condition have declined from near average values in the past 1-2 years, whereas no trend in growth rate has been observed for 3NO.

Habitat Requirements and Suitability

Residence Requirement

Definition from *Species at Risk Act* 2(1) defines a residence as - A dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating.

Cod do not have any known dwelling-place similar to a den or nest during any part of their life-cycle. Therefore, the concept of residence does not apply.

Habitat Properties

Habitat use by Atlantic Cod varies significantly by life stage and size. Latitudinal gradients in development rates (spawning times, egg development rates, and growth rates of all life stages), influence habitat use patterns in the species. Physical habitat associations are the strongest at the demersal juvenile stage (4-35 cm long).

Eggs and larvae

Egg and larval distributions are determined by the spawning locations of adult cod and subsequent action by prevailing oceanographic currents and non-density dependant forces. Eggs are typically found in the upper surface layers of the water column. There is no evidence to suggest that they are associated with particular physical habitat features.

Juveniles

Cod assume more active control of their movements at the pelagic juvenile stage. It remains unknown to what extent individuals exhibit directional movements which might determine where they settle to the seabed. Prevailing evidence suggests that oceanographic currents and retention mechanisms have a dominant role on distribution.

The demersal juvenile stage is the most habitat-dependant period in the life-cycle of Atlantic Cod. Association with specific habitat features and habitat components is of greater importance in demersal juveniles after settlement to the seabed. In western Atlantic waters, settlement occurs in both coastal and offshore location in the southern portion of the range, whereas in the north it occurs predominantly in coastal areas. Within the Newfoundland and Labrador DU settlement is known to occur in both inshore and offshore areas, in the south, but is increasingly limited to inshore waters north of the Grand Banks. It appears that area of settlement may be related to temperature conditions which affect growth.

Within these broader geographic considerations, demersal juvenile cod associate with seabed habitats which provide cover from predators - physically complex habitats among those available. There is evidence to suggest that structurally complex habitat reduces mortality rate and is preferred by demersal juveniles. Inshore, vegetation - eelgrass and macroalgae - is important. In both inshore and offshore areas, pebble-gravel and rock-boulder areas within a patchy marine landscape are significant habitats for demersal juveniles.

There is evidence that juvenile cod do saturate local habitat and their densities affect recruitment to subadult life stages. Therefore, the amount of habitat likely defines an upper threshold carrying capacity within the life stage.

Adult

Evidence of habitat use by adult Atlantic Cod is limited to seasonal movements or migratory patterns typically following specific thermal ranges or oxygen levels near the seabed. Although they are widely distributed throughout the Newfoundland and Labrador DU, adult cod are associated with specific bathymetric features near the shelf break, and other areas with high prey concentrations.

Overwintering areas tend to be in deeper warmer waters.

Spawning Adults

Over the species range spawning cod have been observed both in the offshore and inshore waters in large aggregations at all times of the year depending on location. Most spawning occurs in a two to three month long period, which may be specific to location. Individuals are batch-spawners. There is little consistency in spawning depth among areas. There is no correlation of location or timing of spawning to temperature. There is evidence for coupling of spawning times with high secondary productivity.

The specific seabed habitat features that influence affinity to a specific area are not well known. Spawning locations are thought to be associated with oceanographic features such as gyres or currents that retain eggs and larvae, or distribute them to locations where conditions are generally good for the early life-history stages. Specific spatial locations, which are stable in time, suggest there are distinctive features about these locations leading spawners to choose them repeatedly. We do not currently know what constitutes "the habitat" for spawning cod, other than it quite often happens in the same place annually.

Spatial Extent of Habitat

The geographic distribution of Atlantic Cod ranges from Cape Hatteras, North Carolina to Greenland on the western Atlantic and the Barents Sea south to Spain and Portugal on the eastern Atlantic. Older juveniles and adults are widespread throughout the Canadian portion of the historical range of the species, indicating that some amount of suitable habitat exists within this range. However, very little information is currently available at the appropriate spatial resolution to identify the extent of the habitat available to demersal juvenile Atlantic Cod – such as gravel and cobble, eelgrass beds or macroalgae – especially in the offshore. There is no indication that the amount of suitable habitat is currently limiting recovery of cod.

Activities that Might Threaten Habitat

In general, potential for anthropogenic disturbance is highest in the coastal zone and with proximity to human population centers and industrial activity. Natural mortality of demersal juveniles can increase significantly with loss of habitat structure. Habitat alteration in the form of physical disturbance to structural components of habitat such as complex living habitat (e.g., corals, eelgrass and macroalgae) and some physical seabed features (e.g., fine scale geological bedforms) can reduce its function of providing cover from predators, therefore decreasing its value.

Mobile bottom-contact fishing gears do have impacts on benthic populations, communities, and habitats. The effects are not uniform, but depend on at least the specific features of the seafloor habitats, including the natural disturbance regime; the species present; the type of gear used, the methods and timing of deployment of the gear, and the frequency with which a site is impacted by specific gears; and the history of human activities, especially past fishing, in the area of concern.

Other gears including those that do not contact the bottom may still have an effect but the severity of any impact will depend on the nature of the impact (i.e. what is impacted and in what way); the location and scale of the fishery and how the gear is rigged, deployed, and retrieved.

Eutrophication is a threat in areas of the nearshore and also in some areas of the inshore. Eelgrass beds and macroalgae can be impacted by anthropogenic eutrophication, sedimentation, and contaminants.

Oil and gas development may cause physical disturbance or contamination of habitat.

Impact of Potential Habitat Changes

Limitations in the quantity of habitat available and interannual variation in predator and prey abundance can create bottlenecks to demersal juvenile survival.

Juvenile cod mortality rate is very high in non-complex habitat, compared to complex habitats nearby. The ecological significance of complex habitat on survival of demersal juvenile cod cannot be overstated. Complex habitat represents a buffering effect on populations, especially at low abundance. Evidence that demersal juvenile cod can attain a carrying capacity limit has been demonstrated at local scales in coastal waters; however, this appears to be rare and is unlikely to be a common occurrence across an entire DU.

Reduced landscape complexity in eelgrass beds leads to reduced demersal juvenile densities and carrying capacity within habitat. The impact of reduced landscape complexity for other habitat components is unavailable.

Spatial Configuration Constraints

Spatial configuration constraints such as connectivity and barriers to access are not a current limiting factor for Atlantic Cod recovery.

Amount of Suitable Habitat

Older juveniles and adults are widespread throughout the Canadian portion of the historical range of the species, indicating that some amount of suitable habitat exists within this range. However, very little information is currently available at the appropriate spatial resolution to identify the extent of the habitat available to demersal juvenile Atlantic Cod – such as gravel and cobble, eelgrass beds or macroalgae – especially in the offshore. There is no indication that the amount of suitable habitat is currently limiting recovery of cod.

Feasibility of Habitat Restoration

It is technically feasible to undertake restoration of coastal habitat in localized areas. However, there is no indication that such restoration is required for population recovery.

Habitat restoration to higher values would likely be focused in shallow environments (e.g., coastal environment). Introduced materials (e.g., rocky reefs) and restored shoreline and eelgrass restorations and transplants have been successful in other countries and also in Canada.

Natural expansion of some vegetated habitat is known to be accompanied by increased demersal juvenile density. Therefore, it is possible to consider such options on small local scales.

Risks Associated with Habitat "Allocation" Decisions

The degree to which a habitat can be defined as a discrete area with clear edges or a gradient of features in the marine environment has not been identified. The associated risks of habitat allocation decisions have not been evaluated for Atlantic Cod. However, as noted earlier, there is no indication that the amount of suitable habitat is currently limiting recovery of cod.

Impact of Threats on Quality and Quantity of Available Habitat

Older juveniles and adults are widespread throughout the Canadian portion of the historical range of the species, indicating that some amount of suitable habitat exists within this range.

Habitat alteration, especially physical alteration or loss of structurally complex seabed habitat will reduce its value. Threats to cod habitat include physical disturbance to complex living habitat and physical seabed features, eutrophication, invasive species and shoreline development.

Natural mortality of demersal juveniles can increase significantly with loss of habitat structure. Habitat alteration in the form of physical disturbance to structural components of habitat such as complex living habitat (e.g., corals, eelgrass and macroalgae) and some physical seabed features (e.g., fine scale geological bedforms) can reduce its function of providing cover from predators, therefore decreasing its value. Due to the current lack of knowledge of distribution and quantity of structurally complex habitat, especially in the offshore, we have little understanding of how much these habitats may have been altered by human and natural disturbances in the past. The specific effects of any particular threat on productivity of cod habitat are even less clear. There is no indication that the amount of suitable habitat is currently limiting recovery of cod.

The permanent loss of some habitat components will have a disproportionate negative effect on cod populations. Eelgrass is a DFO-Ecologically Significant Species. It is known to be important in near shore areas for small demersal juvenile cod in much of its range. The impact of loss of this habitat is known to be high. Impacts of possible losses for other habitat components have not yet been determined.

Fishing gears and eutrophication also affect the quality and quantity as described under the section above 'Activities that Might Threaten Habitat'.

Invasive species present a significant local threat in some areas in which they have been observed. Invasive Green Crab (*Carcinus maenas*) is a known threat in shallow coastal waters. The species can destroy eelgrass beds by uprooting the plants. Through alteration of habitat and bottom cover, they may increase the mortality of demersal juvenile cod. Green Crab is found within the Newfoundland and Labrador DU, notably at the head of Placentia Bay.

Other invasive species can overgrow marine vegetation, reducing its function of providing cover from predators, therefore decreasing its value. There have been no specific threats to cod habitat identified in offshore areas.

SARA and Management Considerations

To explore the potential for recovery from both a SARA and a fisheries management perspective, a number of projections of future stock dynamics were undertaken for the 2J+3KL and 3NO populations. For SARA considerations, these populations represent a large majority of the NL DU.

Limit Reference Point

The conservation limit reference point (LRP) is the SSB below which the stock is considered to have suffered serious harm, as the probability of good recruitment is low.

An LRP for 2J+3KL cod was determined at the "Atlantic Cod Framework Meeting, Reference Points and Projection Methods for Newfoundland Cod Stocks" held in St. John's, NL, in Nov. 2010 (DFO 2011a). The Precautionary Approach (PA) reference point, B_{lim}, was established to be 55 kg per tow of mid-year SSB. For Div. 3NO cod, the LRP (B_{lim}) was established to be 60,000 t of SSB by NAFO Scientific Council in 1999 (ANON., 1999).

Recovery targets should correspond to mature biomass levels well beyond B_{lim}, which defines the critical zone under the DFO PA Framework. Consequently, the time required to recover to these currently undefined targets will exceed the time required to reach B_{lim}.

Projections at Current Productivity

From a SARA perspective, projections were conducted to explore the risk of further decline in mature stock numbers at the DU level.

The results of this RPA are mainly based on projections of stock size over 36 years as specified in the Terms of Reference (ToR). Long-term projections are dominated by process error (uncertainty in recruitment rates, mortality rates, etc.) so that their utility is not in providing probabilities of specific outcomes but rather in defining the uncertainty.

Future productivity conditions are very uncertain. Thus, these projections should not be interpreted as forecasts of future stock status because they depend on assumptions about future productivity and fishing mortality. The probability of current conditions continuing for a long period of time is unknown. These projections are explorations of the consequences of particular productivity assumptions.

For the 2J+3KL and 3NO cod populations, projections of stock dynamics were conducted, based on population estimates from the most recent assessments as noted above. Six projections were considered based on the ToR : fishing mortality over 36 yrs was held constant at values corresponding to $F_{current}$ and reductions of 25%, 50%, 75%, 95%, and 100% from $F_{current}$. For 2J+3KL $F_{current}$=0.06 and for 3NO $F_{current}$=0.07 (DFO 2011a). Biological inputs were randomly sampled using a 'backward expanding window' approach covering the 1983 to 2009 period. The objective of this approach is to make conditions at the beginning of the projection period comparable to the recent conditions, but allow for a broader range of productivity conditions to be re-sampled as plausible scenarios for the future. Due to the low fishing mortalities in both stocks, only F=0 and $F_{current}$ results are described herein because there would be little contrast if intervening values of F were evaluated.

Projections for management considerations

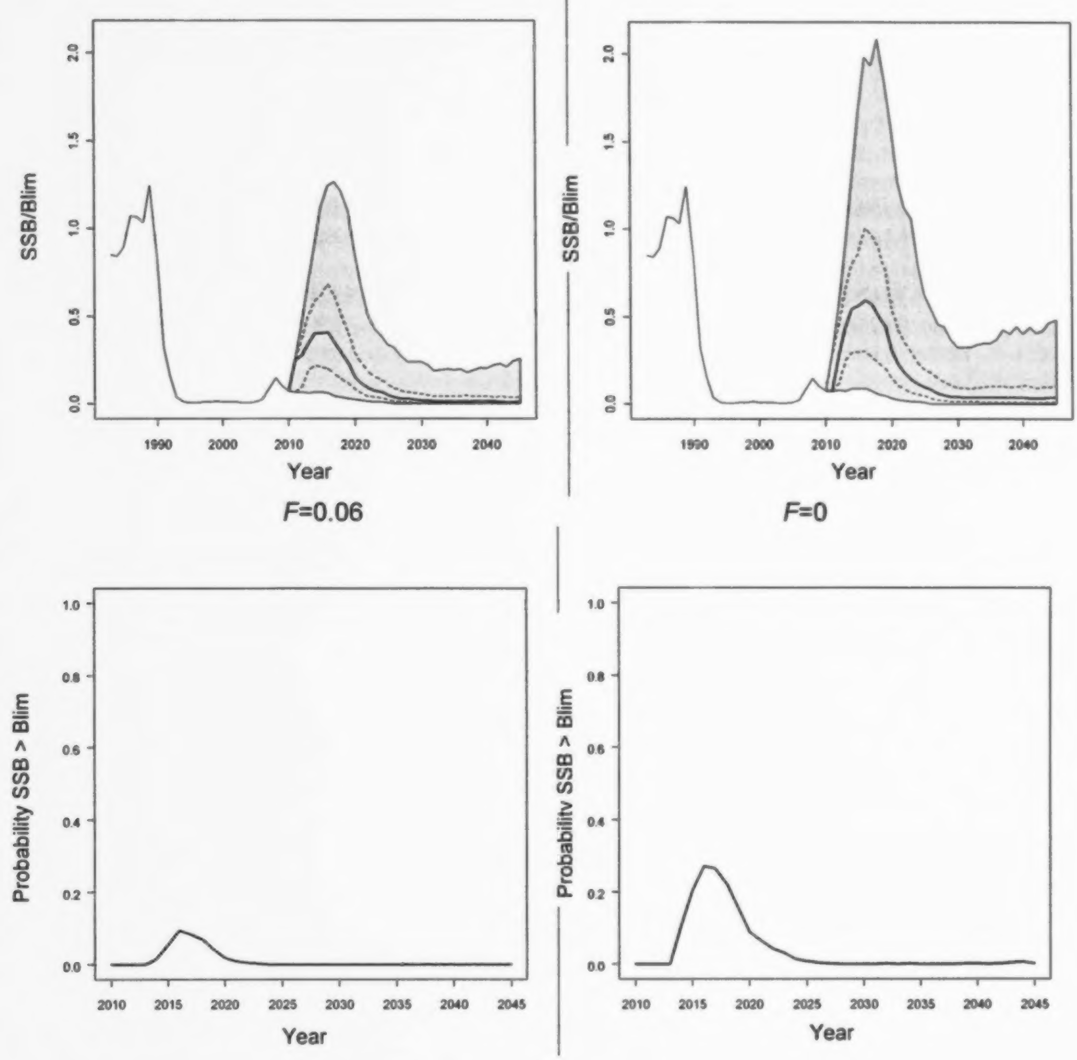


Figure 9. 2J+3KL cod - Thirty-six year projection of SSB relative to B_{lim} assuming fishing mortality remains constant at current levels (F=0.06, upper left panel), or is zero (F=0, upper right panel). The 2.5th, 25th, 50th (solid line), 75th and 97.5th percentiles of SSB relative to B_{lim} are shown in the projection period (grey area). The probability that projected SSB exceeds B_{lim} under each scenario is indicated for F=0.06 (lower left panel) and F=0 (lower right panel). These projections are conditional on productivity conditions as described in the text.

For the 2J+3KL stock, under the current fishing mortality rate (*F*=0.06), the projection median estimates indicate an initial increase in SSB followed by a decline and stabilization at a level lower than current SSB (Fig. 9). At the peak of the increase in 2016, there is a low probability (<10%) that the stock will reach B_{lim} before declining. The initial increase is a result of marginally improved recruitment and lower *M* in the most recent period. However, the increase is short-

lived. As the projection re-sampling window expands, the influence of high natural mortality in the pre-2003 period dominates and the stock declines. After 36 years, the median projected SSB is 99% below B_{lim}. Under F=0, the projection trends are similar but only marginally more optimistic; at the peak of the increase there is a low probability (about 30%) that the stock will reach B_{lim} before declining, and at the end of the projection period the median projected SSB is 96% below B_{lim}.

There is uncertainty about how to model biological parameters in the projections. This was partly accounted for by using the expanding window approach described above. Additional sensitivity analyses were conducted around this window approach. The results of four subsets of input parameters are listed as follows:

(1) Only consider the most recent 10 years in the expanding re-sampling window, with F=0: results were similar to the base projection.

(2) Only the most recent 5 years in the expanding re-sampling window (most optimistic productivity scenario), with F=0.06 and F=0: at least 65% of the results suggest B_{lim} will be exceeded in the next 36 years under F=0 and at least 40% of the results exceed B_{lim} for F=0.06.

(3) Only consider sampling from the worst 5 years for M, with F=0: results indicated the stock collapses rapidly from the 2010 level.

(4) Consider all years as equally likely to be sampled, with F=0: results indicated the stock declines continuously from the 2010 level and there is a negligible chance it will exceed B_{lim} by 2045.

The sensitivity analyses were conducted to demonstrate the impact of using different historic periods to infer productivity conditions in the projections, particularly related to values for M.

The causes of changes in productivity since 2003 are unknown, and the persistence of these new conditions cannot be predicted. However, it is less likely that conditions in the recent period will persist the further the projection proceeds into the future. Therefore the expanding window approach over 1983-2009 period was considered to be appropriate.

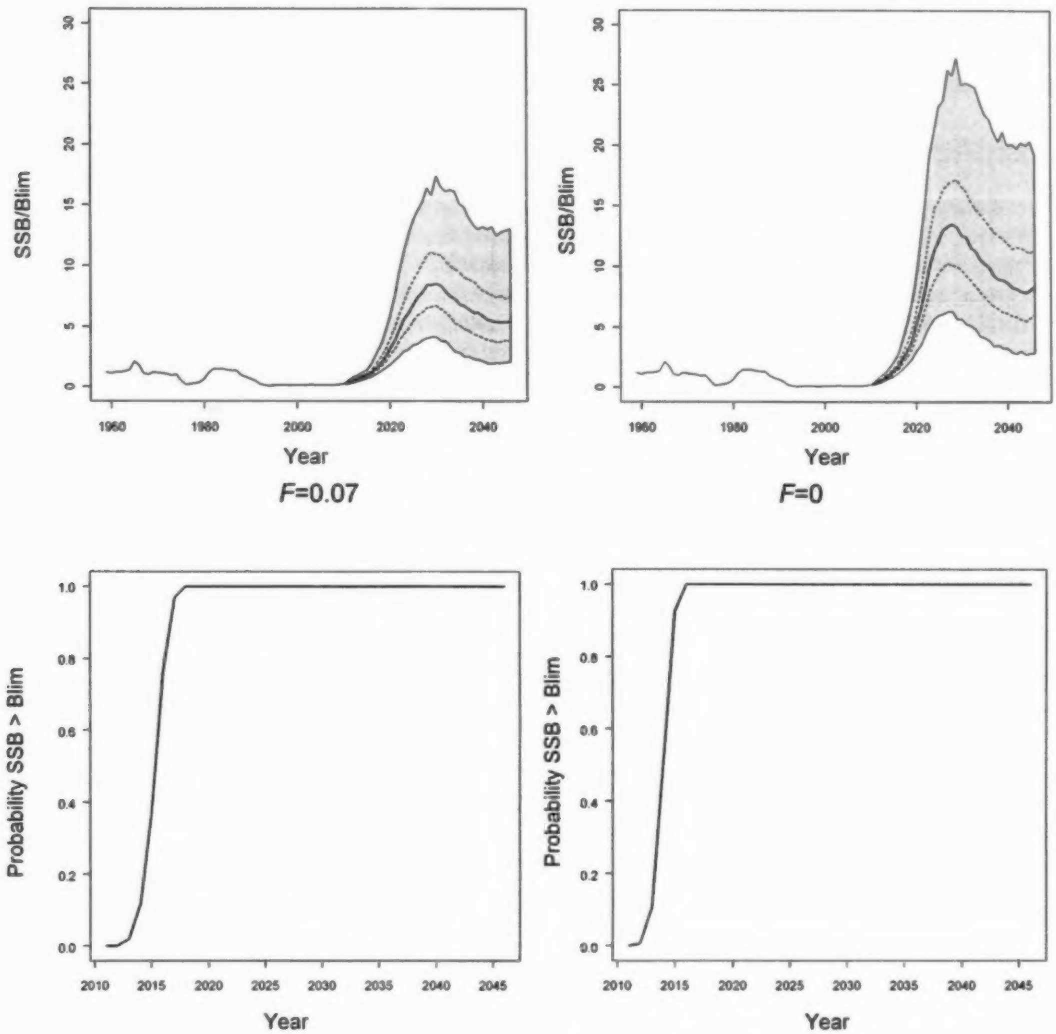


Figure 10. 3NO cod - Thirty-six year projection of SSB relative to B_{lim} assuming fishing mortality remains constant at current levels (F=0.07, upper left panel), or is zero (F=0, upper right panel). The 2.5^{th}, 25^{th}, 50^{th} (solid line), 75^{th} and 97.5^{th} percentiles of SSB relative to B_{lim} are shown in the projection period (grey area). The probability that projected SSB exceeds B_{lim} under each scenario is indicated for F=0.07 (lower left panel) and F=0 (lower right panel). These projections are conditional on productivity conditions as described in the text.

For 3NO, under the current fishing mortality rate (*F*=0.07) there is a sustained rapid increase in SSB (Fig. 10) and all projection results suggest that B_{lim} is surpassed by 2016. The immediate increase is driven by the survivors of 2010, most notably the strong 2006 year-class which is comparable to those from the mid-1980s. Median SSB peaks at about 8.5 times higher than B_{lim} in 2030. The continued increase beyond 2016 is driven primarily by recruitment generated from the improved recruit/spawner estimates from the recent period and 95% of all projection results

suggest SSB would be two times B_{lim} by 2021. For the F=0 scenario, the trends in the results are similar but the median SSB peak is 12.5 times higher than B_{lim}. These projections show that the stock has potential to grow to a level that is well beyond its highest estimated historic size. However, the stock will be constrained biologically at least by carrying capacity and additional fishing mortality that would be anticipated.

Projections for SARA considerations

Projections were undertaken to explore the risk of further decline in mature stock numbers at the DU level under the constant F scenarios as described above for the fisheries management considerations.

The DU estimates of SSN were derived as area-weighted averages of the 2J+3KL and 3NO estimates. The 3NO cod abundance estimates were adjusted to the scale of the 2J+3KL estimates (survey mean numbers per tow). These results could only be evaluated back to 1983 as a reference year because this is the start of the 2J+3KL SSN series.

Probabilities of no further decline were calculated beginning with the first possible 36 year comparison (2019 compared to 1983) then moving the window forward one year at a time until 2045. A high probability of this occurring is offered here as an indication that a DU (or a species) may no longer be at risk and would require further evaluation.

Under $F_{current}$ within each population (F=0.06 for 2J+3KL and F=0.07 for 3NO), the results suggest median SSN increases steadily and peaks in 2026 (Fig. 11, upper left panel). The probability of no decline is initially low (~20%) in 2019 but increases to 100% by 2027 (Fig. 11, lower left panel). Under the F=0 scenario (Fig. 11, right panels), overall trends are similar except the scale of the relative population numbers are higher and the probability of no decline is initially high (~65%) in 2019 and increases to 100% by 2027.

Although the historic 2J+3KL stock was much larger than the 3NO stock, these results at the DU level are dominated by the much more optimistic trajectory in 3NO.

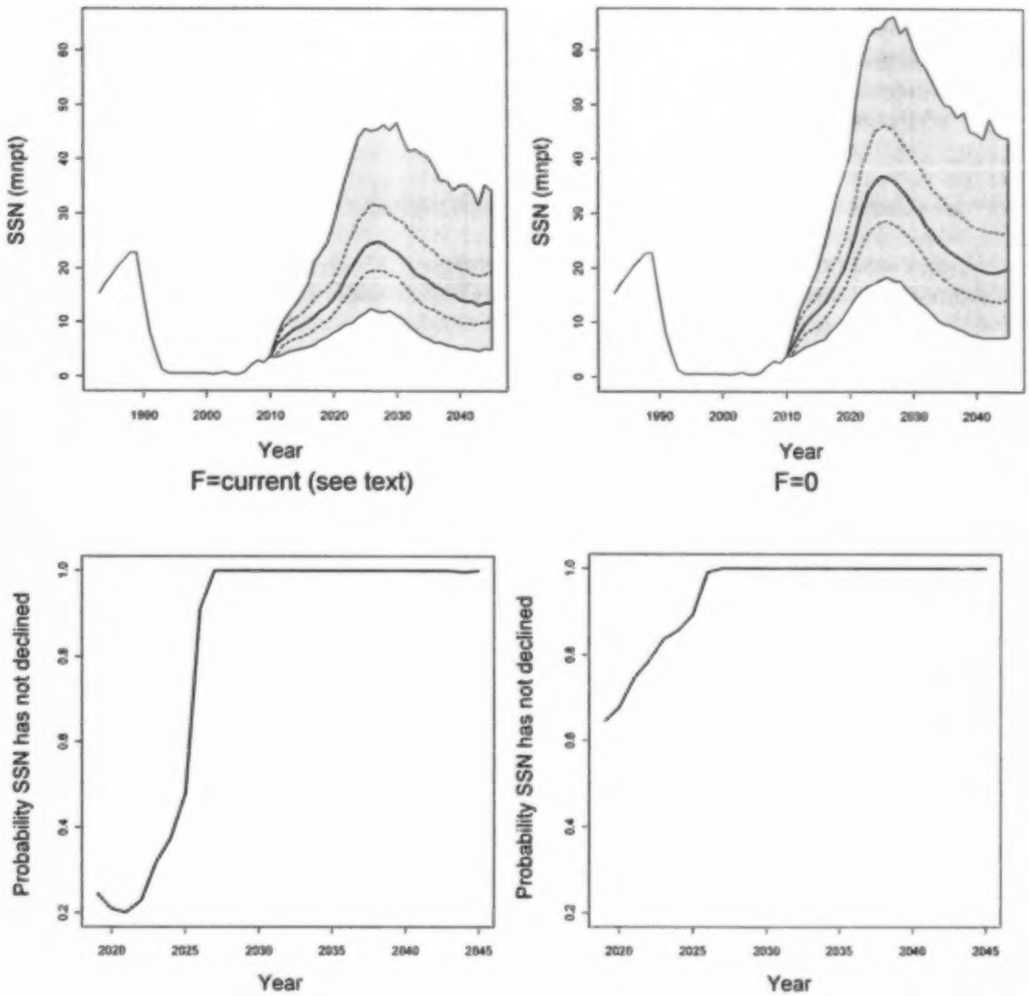


Figure 11. 2J+3KL and 3NO cod: Thirty-six year projections for the NL DU (2J+3KL and 3NO stocks combined) illustrating Spawning Stock Numbers (SSN) assuming fishing mortality remains constant at current levels (upper left panel), or is zero (upper right panel). The 2.5th, 25th, 50th (solid line), 75th and 97.5th percentiles of SSN are shown in the projection period (grey area). The probability that projected SSN has increased over each thirty-six year period is indicated for $F_{current}$ (lower left panel) and F=0 (lower right panel). These projections are conditional on productivity conditions as described in the text.

Threats to Survival and Recovery

2J+3KL

Although current levels of natural mortality appear low, the stock in 2J+3KL has shown long periods during the moratorium when natural mortality was high and this remains a significant threat to the recovery. The source of the high level of natural mortality remains unclear. It is a common belief that harp and hooded seals as well as cetaceans could be important component but there is a high level of uncertainty surrounding the impact of marine mammal consumption on cod dynamics and the impact could also be indirect through competition for key prey such as Capelin. Populations of harp seals are estimated with high uncertainty to be about 9 million animals (G. Stenson, DFO, pers. comm.) and some cetacean species have recently increased. Collectively they consume huge quantities of prey and are potential threats to cod recovery. The relative impact of marine mammals on natural mortality of cod, whether direct or indirect, is not quantified.

Although current levels of F are low, directed fishing through stewardship and recreational fisheries also remains a significant potential threat to survival and recovery of 2J+3KL cod.

Bycatch is also a threat to recovery for 2J+3KL cod.

3NO

Although current levels of F are low, bycatch fisheries over the period of the moratorium generated high levels of F coincident with pulses of improved recruitment that contributed to lack of recovery since the moratorium. Therefore, fishing remains a potential threat to the survival and recovery of 3NO cod.

For 3NO cod, management measures in areas outside the 200-mile Exclusive Economic Zone of Canada are decided by the Northwest Atlantic Fisheries Commission, which has jurisdiction of this portion of 3NO. Although the NAFO Fisheries Commission is developing a rebuilding plan for 3NO cod, it is unknown whether measures adopted there will be sufficient to meet the objectives of any recovery plan implemented in Canada to address SARA considerations.

Entire DU

In addition to the potential threats outlined above for each stock within the DU, for both 3NO and 2J+3KL age-at-maturity has declined and remained low and increased mortality associated with spawning at these younger ages may be expected.

Limiting Factors for Population Recovery

Mortality

Although levels of total mortality (Z) have been lower during 2005-08, levels of total mortality were high during much of the post-moratorium period and are considered a major impediment to recovery of northern cod. The level of natural mortality (M) is thought to be much lower in the recent period, but the main factors influencing the level of natural mortality are not known.

Recruitment

Recruitment in 2J+3KL has been low since the late 1980s and this has contributed to the current low productivity of the stock. The stock is well below the LRP and has not produced good recruitment since the SSB declined rapidly in the late 1980s and early 1990s. The low age at maturity may also be contributing to the low recruitment as younger spawners are less effective at producing recruits.

Recruitment was also low for several years in 3NO, but with the appearance of two reasonably strong year classes in the mid 2000s this aspect of productivity has improved. Further strong year-classes would be required for the 3NO population to undergo a sustained recovery.

Environmental factors

The impact of natural factors such as climate change could potentially impact the productivity of the stock in unpredictable ways and influence recovery. Extremes of warm or cold can affect ecosystems in many ways and change productivity conditions, distributions, and mortality rates. For example cold conditions in the early 1990s were associated with lower growth rates and condition in many cod stocks, including 2J+3KL.

Mitigation and Alternatives

Fishery Management

Currently there is a moratorium in the offshore 2J+3KL area and in 3NO. A directed stewardship fishery exists in the inshore area of 2J+3KL.

Mitigation measures for reducing directed fishing mortality include: the implementation of the Precautionary Approach (PA); the development and adoption of harvest control rules and decisions compliant with the PA in the Integrated Fisheries Management Plans for all cod stocks; catch limits for commercial, index or stewardship fisheries; creating zones to protect high concentrations of individuals; limiting participants and/or fishing effort by restricting the number of boats or gear allowed; and, maintaining or creating no fishing zones during certain times of the year in areas where cod spawn. Consider establishing a Marine Recreational Licence system to improve the basis to assess the level of cod caught by this type of removals.

A number of these mitigation measures are already being considered or have been applied in the NL DU within Canada's 200-mile limit. The 3NO stock is managed through the NAFO and a rebuilding plan is currently being considered by the NAFO Fisheries Commission.

Bycatch and Discards

Mitigation measures for reducing bycatch and discards of cod include the application of Bycatch and Small Fish Protocols as well as measures included in Conservation Harvesting Plans (such as gear type, mesh size, percent or weight of allowable incidental catches per trip in certain areas or during certain time of the year); adopting more stringent requirements for the management, control and monitoring of bycatch in other directed fisheries; continuing efforts to improve the Dockside Monitoring Program, increasing observer coverage in directed cod fisheries when (and where) the catch and discarding of small fish is likely to be high; conducting a review, in conjunction with industry, of additional measures such as seasonal closures or

gear restrictions to address the discarding of fish; mandatory hail out; completion of log books. In addition, expansion of the requirement for Vessel Monitoring Systems (VMS) and increased compliance monitoring activities (such as Dockside Inspections, At-Sea Inspections and Aerial Surveillance) to ensure that bycatch restrictions for moratorium species are adhered to in 3NO and offshore areas of 2J+3KL.

Allowable Harm Assessment

In consideration that both populations have recently shown increases, there appears to be scope for allowable harm permitting, if current levels of productivity continue. Catches that have resulted in current levels of fishing mortality, (estimated as F=0.06 for 2J3KL cod, F=0.07 for 3NO cod), would not appear to be sufficient to jeopardize survival or recovery of the species in the short term (3-years) if current productivity continues in these stocks. This should allow sufficient time for recovery plans to be developed. Projections under higher levels of fishing mortality were not conducted given that each of these stocks are well below their LRPs (2J3KL: current SSB is 90% below B_{lim}; 3NO: current SSB is 79% below B_{lim}).

To provide a species at risk context, increase in mature numbers was evaluated over the span of a 36-year period where the difference between SSN at the beginning and end of the period was calculated for each iteration in the projection. Given the data series from each stock can only be combined at the DU level from 1983 onwards, the first possible comparison period for a "36-year net increase" is 1983 to 2019 and the last is 2009-2045.

The following table summarizes the results by stock and for the DU as a whole.

<table>
<tr><th></th><th colspan="4">Probability of number of years to reach B_{lim}:</th><th colspan="2">NL DU: Evaluating increase in SSN over 36-year periods</th></tr>
<tr><th rowspan="2">Reduction in Fishing Mortality from $F_{current}$</th><th colspan="2">2J+3KL Cod: B_{lim} (55 kg/tow survey SSB) $F_{current}$=0.06</th><th colspan="2">3NO Cod: B_{lim} (60,000t SSB) $F_{current}$=0.07</th><th colspan="2">Median number of years to realize a period of increase with a probability of:</th></tr>
<tr><th>50%</th><th>95%</th><th>50%</th><th>95%</th><th>50%</th><th>95%</th></tr>
<tr><td>100% (F=0)</td><td>>36</td><td>>36</td><td>3</td><td>5</td><td>9[1]</td><td>14</td></tr>
<tr><td>50%</td><td>>36</td><td>>36</td><td>4</td><td>5</td><td>10</td><td>16</td></tr>
<tr><td>0% ($F_{current}$)</td><td>>36</td><td>>36</td><td>5</td><td>6</td><td>13</td><td>17</td></tr>
</table>

[1] first possible 36-year period to compare for DU combined data series

For the 2J+3KL stock, under the most optimistic scenario of no fishing, SSB does not reach B_{lim} with a certainty as high as 50% within the next 36 years. For 3NO, B_{lim} is reached with a 95% certainty in 5 years under F=0 and in 6 years under F=0.07.

Other potential sources of harm (such as habitat alteration, oil exploration and production, pollution, shipping, cables and lines, military activities, ecotourism, fisheries on food supplies; scientific research, aquaculture; introductions & transfers) were not specifically quantified in this assessment but are considered to have relatively low impacts on the ability of cod to survive and recover, relative to the impact of the fishery.

Sources of Uncertainty

The 36-year projections at either the stock or DU level are subject to the uncertainties common to stock assessment: the uncertainty in the current stock size and the factors affecting future productivity. The factors affecting biological production (reproduction, mortality, growth) have varied over time and future conditions are difficult to predict. In addition, assumptions that population(s) will respond to the future physical and biological environment as it did in the past may not be valid due to the effects of climate change and/or other external processes.

These projections differ from those normally requested in stock assessment because of the requirement to project 36 years into the future. Nevertheless, over the short term (3-5 years into the projection), the results are primarily determined by mortalities applied to current estimates of year classes compared to the longer term (10+ years into the projection) which are totally dependent on predicting recruitment, making those results even more uncertain. In addition, users of these results are advised that not all sources of uncertainty have been addressed in these projections such that the true uncertainty is even greater than that presented here.

Methods appropriate for long-term projections were employed here; therefore, interpretation of these results for only the first few projected years underestimates the uncertainty that would be included for purposes of short-term projections.

The assessment method applied to 2J3KL cod estimates total mortality (*Z*) annually. The long-term projections conducted to evaluate recovery potential required an estimate of natural mortality (*M*) as one of the biological inputs in a future year, and this was selected randomly from a past year. Natural mortality was derived from total mortality estimated from the assessment model using the relationship $M=Z-F$. For the moratorium years, from 1993-2009 fishing mortality (*F*) was assumed to be 0.06 based on a recent tagging estimate of exploitation. For the pre-moratorium years 1983-92 the value of *M* was assumed to be 0.2. The results of the projections are conditional on this as well as other assumptions.

For 3NO projections, *M* is held constant at 0.2 consistent with that used in the VPA assessment model. Although there have been no specific studies focusing on *M*, there is no evidence from the assessment model diagnostics that would suggest that *M* has changed over time within 3NO.

Total annual catch of cod in 2J+3KL is uncertain. Commercial fishers often report that stewardship fishery landings are underestimated. In addition, there are no direct estimates of recreational landings for 2009 and estimates for other years (2007, 2008) are uncertain. Recreational catches could be a significant fraction of total removals in the recent period. Accurate catch information could reduce uncertainty in evaluations of the impact of fisheries on stock growth.

Knowledge of the amount and spatial distribution of available habitat for demersal juvenile Atlantic Cod is currently unavailable at the spatial scales with which juveniles are likely to be using it. The spatial resolution of most of our available seabed habitat knowledge is on the order of tens of kilometers. In contrast, demersal juvenile cod are known to associate with seabed habitats at scales of hundreds of meters and less – a mismatch on the order of 100 to 1 in scope at best, especially in the offshore. Therefore, it is not known how much habitat is available for juvenile cod at present.

SOURCES OF INFORMATION

This Science Advisory Report has resulted from a Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Zonal Advisory Meeting of February 21-25th, 2011 on the Recovery Potential Assessment (RPA) for Atlantic Cod (Newfoundland and Labrador, Laurentian North, Laurentian South, Southern Designatable Units). Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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